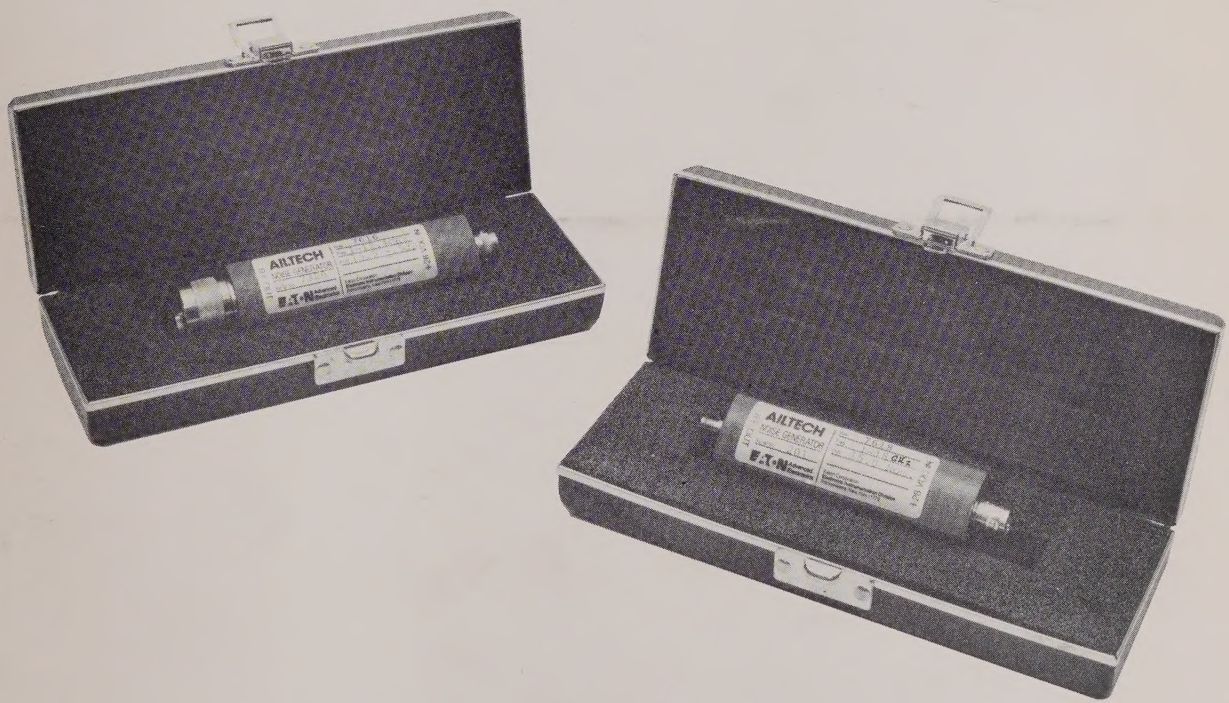
OPERATION AND
SERVICE MANUAL

AILTECH

7600 SERIES
NOISE GENERATORS



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SERVICE MANUAL

AILTECH

7600 SERIES
NOISE GENERATORS

NOVEMBER 1980
REVISED MARCH 1982
REVISED JULY 1983

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Figure 1-1. AILTECH 7600 Series, Solid State Noise Generators

SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual contains operational and service information for the AILTECH 7615, 7616, 7617, 7618, 7618E, and 7626 Solid-State Noise Generators.

1-3. GENERAL DESCRIPTION

1-4. The AILTECH 7600 Series Noise Generators provide accurately calibrated noise levels at frequencies from 10 MHz to 26.5 GHz which can be used to evaluate the noise performance factors of receivers and amplifiers (including subassemblies, modules, and individual devices). The measurement results are usually in terms of Noise Figure (Noise Factor) or Effective Input Noise Temperature.

1-5. The noise generators described by this manual are physically similar. Figure 1-1 is a photograph of the Solid-State Noise Generators. The general external characteristics are indicated below. Specific differences can be extracted from the specification.

Part Number	Frequency Range	Output Connector
7615	10 MHz to 1.5 GHz	N Male
7616	1 to 12.4 GHz	N Male
7617	12.4 to 18 GHz	SMA Female
7618	1 to 18 GHz	SMA Female
7618E	10 MHz to 18 GHz	SMA Male
7626	10 MHz to 26.5 GHz	SMA Male

1-6. All AILTECH 7600 Series Noise Generators are calibrated at each specified frequency by means of the AILTECH 82 Noise Calibration System. This system was reviewed by the National Bureau of Standards (NBS) in 1968 (NBS Report #9729, Error Analysis of the AIL Noise Measuring System, W.C. Daywitt, September 1968). Copies of this report are available from Eaton Corporation, Electronic Instrumentation Division, upon request.

1-7. The calibration system is fully traceable to NBS except for those frequency ranges at which NBS does not offer a calibration service. In these cases, the 7600 Series Noise Generator calibration is traceable to basic, natural, physical phenomena.

1-8. Each AILTECH 7600 Series Noise Generator is accompanied by a Calibration Data Sheet (located under the foam insert of the storage case). Figure 1-2 is a sample of a typical data sheet. In addition, the calibrated excess noise ratio values are marked on a graph of ENR versus frequency affixed to the body of the noise generator. (See Figure 1-3).

CALIBRATION

P/N 7618

S/N _____

Frequency (GHz)	Excess Noise Ratio (dB)
1.0	_____
2.0	_____
3.95	_____
8.2	_____
9.8	_____
12.4	_____
15.0	_____
18.0	_____

Calibration Uncertainty ±0.30 dB

Date _____

Tested By _____

Quality Control _____

EATON Advanced Electronics

SOLID STATE NOISE SOURCE P/N 7618

SPECIFICATIONS

Part Number	7618
Frequency Range	1.0 to 18 GHz
Excess Noise Ratio (ENR)	15.0 dB Nominal
Output VSWR	1.30 maximum
Operating Voltage	28.00 Volts DC
Noise Output Connector	Type OSM, Female
Power Input Connector	Type BNC, Female
Overall Size	1 x 1 x 4 ¼
Voltage Sensitivity	0.1 dB / % Δ V

OPERATING INSTRUCTIONS

The Solid State Noise Source P/N 7618 is designed to be used with an AILTECH 75 Precision Automatic Noise Figure Indicator (PANFI), or 13611 Precision Test Receiver, 7300 System Noise Monitor. The noise source requires regulated +28 VDC at less than 20 ma. See the Instruction Manual for more detail.

Figure 1-2. Sample Calibration Data Sheet

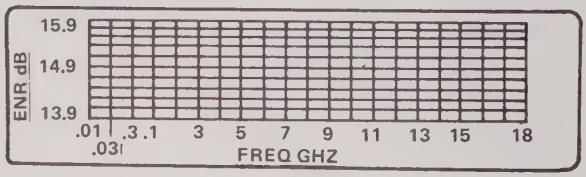


Figure 1-3. Calibration Graph

1-9. The high accuracy of the calibration method and low VSWR at the output of the noise generator combine to provide the user with the potential for extremely accurate noise figure measurements.

1-10. TECHNICAL SPECIFICATIONS

1-11. Table 1-1 is a listing of the general technical specifications of the noise generators covered by this manual. Calibration frequencies and associated worst case uncertainties are shown in Table 1-2 through Table 1.6.

Table 1-1. General Technical Specifications

Part Number	7615	7616	7617	7618	7618E	7626
Frequency Range	0.01-1.5 GHz	1-12.4 GHz	12.4-18 GHz	1-18 GHz	0.01-18 GHz	10 MHz-26.5 GHz
Excess Noise Ratio (nominal, dB)	15.5 dB	15.5 dB	15.5 dB	15.0 dB	15.0 dB	10 MHz to 12.4 GHz: 15.4 dB 12.4 GHz to 18.0 GHz: 14.9 dB 18.0 GHz to 26.5 GHz: 13.0 dB
Flatness versus Frequency	±0.5 dB	±0.5 dB	±1 dB	±1 dB	±1 dB	±0.7 dB ±1.1 dB ±3.0 dB
VSWR (maximum)	1.2	1.2	1.3	1.2, 1 to 12.4 GHz 1.3, 12.4 to 18 GHz	1.2, 0.01 to 12.4 GHz 1.3, 12.4 to 18 GHz	1.10, 10 MHz to 100 MHz 1.15, 100 MHz to 1 GHz 1.17, 1 GHz to 8 GHz 1.25, 8 GHz to 12.4 GHz 1.20, 12.4 GHz to 26.5 GHz
Input Connector	BNC Female	BNC Female	BNC Female	BNC Female	BNC Female	BNC Female
Output Connector	N Male	N Male	SMA Female	SMA Female	SMA Male	SMA Male
Input Power	+28 volts @ 20 mA maximum	+28 volts @ 20 mA maximum	+28 volts @ 20 mA maximum	+28 volts @ 20 mA maximum	+28 volts @ 20 mA maximum	+28 volts @ 20 mA maximum

Table 1-2. Calibration Frequencies and Worst Case Uncertainties, Part Number 7615

Frequency (MHz)	Worst Case Uncertainty (±dB)
30	0.3
300	0.3
1000	0.3
1500	0.3

Table 1-3. Calibration Frequencies and Worst Case Uncertainties, Part Number 7616

Frequency (GHz)	Worst Case Uncertainty (±dB)
1	0.3
2	0.3
3.95	0.28
8.2	0.25
9.8	0.25
12.4	0.25

Table 1-4. Calibration Frequencies and Worst Case Uncertainties, Part Number 7617

Frequency (GHz)	Worst Case Uncertainty (±dB)
12.4	0.25
15	0.25
18	0.25

Table 1-5. Calibration Frequencies and Worst Case Uncertainties, Part Number 7618

Frequency (GHz)	Worst Case Uncertainty (±dB)
1	0.3
2	0.3
3.95	0.28
8.2	0.25
9.8	0.25
12.4	0.25
15	0.25
18	0.25

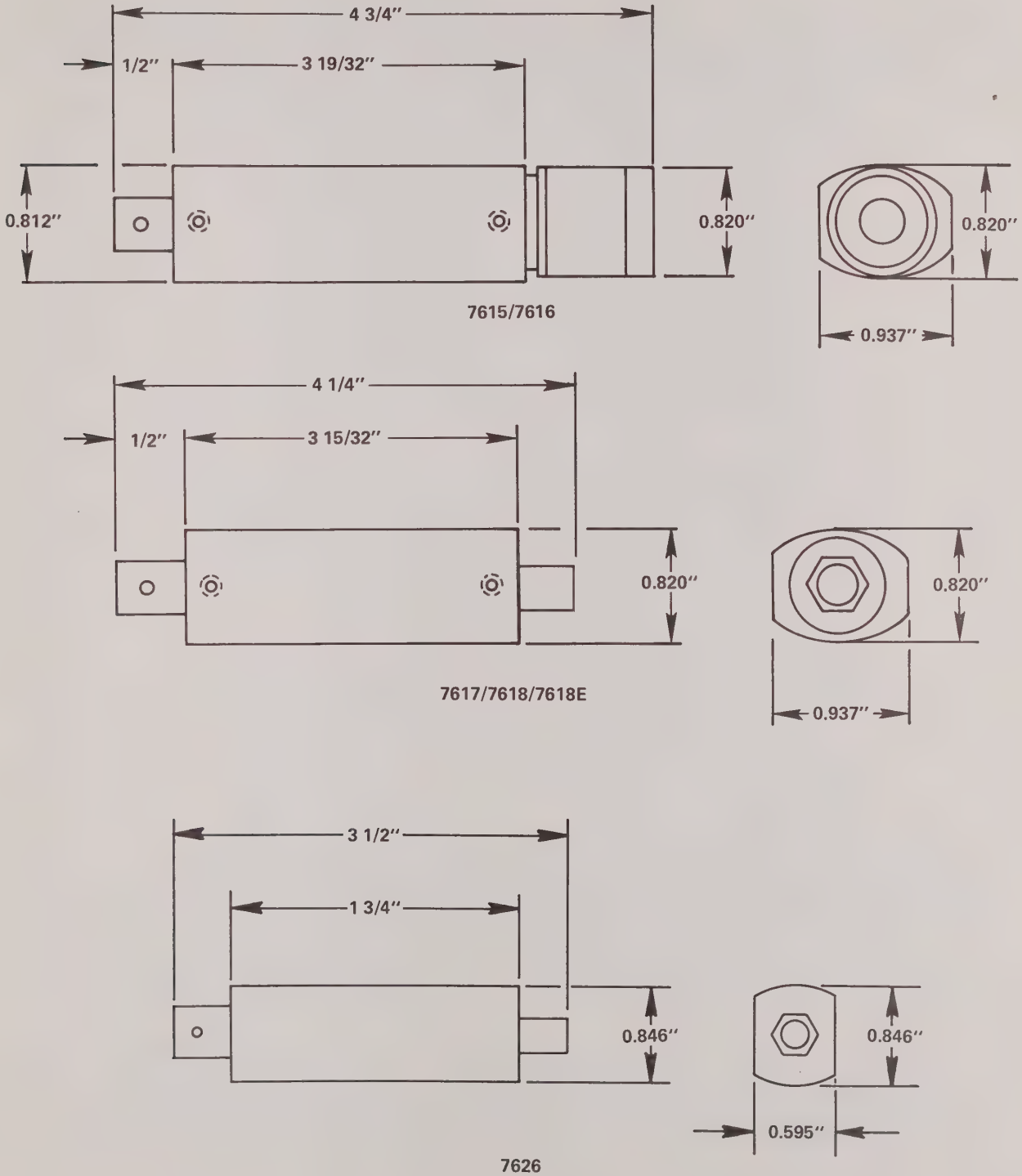


Figure 1-4. 7600 Series Outline Dimensions

Table 1-6. Calibration Frequencies and Worst Case Uncertainties, Part Numbers 7618E and 7626*

Frequency (GHz)	Worst Case Uncertainty (±dB)
0.03	0.3
0.3	0.3
1.0	0.3
2.0	0.3
3.0	0.28
4.0	0.28
5.0	0.3
6.0	0.3
7.0	0.3
8.0	0.25
9.0	0.25
10.0	0.25
11.0	0.25
12.0	0.25
13.0	0.25
14.0	0.25
15.0	0.25
16.0	0.25
17.0	0.25
18.0	0.25
*19.0	0.40
20.0	0.40
21.0	0.40
22.0	0.40
23.0	0.40
24.0	0.40
25.0	0.40
26.0	0.40

1-12. SUPPLEMENTAL CHARACTERISTICS

1-13. Table 1-7 lists additional supplemental characteristics applicable to the 7600 Series Noise Generators covered by this manual.

Table 1-7. Supplemental Characteristics

Temperature Sensitivity	0.01 dB/°C
Voltage Sensitivity	0.1 dB/%ΔV
Turn-on Time	$< 5\ \mu s$
Turn-off Time	$< 5\ \mu s$
Operating Temperature Range	0 to 55°C
Weight (7615, 7616, 7617, 7618E)	3 oz. (85 gr.)
Weight (7626)	2 oz. (56.7 gr.)
Size	See Figure 1-4

1-14. OPTIONS

1-15. The 7600 Series Noise Generators can be provided with additional calibration points other than those noted in Tables 1-2 through 1-5. These calibrations are designated *Standard* or *Precision.* Consult the factory for additional details. Table 1-8 shows the worst case ENR uncertainties for both types of calibration.

Table 1-8. Uncertainties Versus Frequency

Frequency Range GHz	Worst Case Uncertainty ±dB	
	Standard	Precision
0.01 to 2.6	0.30	0.27
2.6 to 3.95	0.28	0.23
3.95 to 8.2	0.30	0.28
8.2 to 18.0	0.25	0.15

1-16. In the frequency range 2.6 to 3.95 GHz and 8.2 to 18 GHz the calibrations are traceable directly to the National Bureau of Standards. At other frequencies, the calibrations are based on the temperatures of boiling water and boiling liquid nitrogen. These primary natural phenomena are the basic standards for noise measurements and are incorporated in the AILTECH 7009 Hot-Cold Standard Noise Generator used for these calibrations.

1-17. ACCESSORIES

1-18. Connections to the 7600 Series Noise Generators are by means of standard coaxial connector series; therefore, interconnecting cables or accessories are not furnished with these units.

SECTION 2

INSTALLATION

2-1. INTRODUCTION

2-2. This section describes unpacking, inspection, preparation for use and initial checkout of the AILTECH 7600 Series Noise Generators.

2-3. UNPACKING, INSPECTION AND DAMAGE CLAIMS

2-4. No special instructions or precautions are necessary for unpacking the Noise Generator; the instrument is ready for use immediately upon receipt. The following checks should be made to insure that no damage has occurred during shipment.

1. Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.
2. Inspect the Noise Generator for physical damage.
3. If damage is not apparent until after the instrument has been accepted, file a claim for concealed damage with the carrier within 5 days after receipt. All packaging material must be kept for inspection by the carrier's agent. A copy of the claim must be forwarded to Eaton Corporation, Electronic Instrumentation Division.

2-5. ANCILLARY ITEMS

2-6. Each 7600 Noise Generator is packed in a plastic storage case and is accompanied by a Calibration Record (stored under the foam insert in the storage case) and one copy of this manual.

2-7. PREPARATION FOR USE

2-8. No special preparations are required to put the Noise Generator into operation other than connecting it to a regulated +28 volt source – available in all AILTECH noise measuring instruments.

2-9. INITIAL CHECKOUT

2-10. Because of the complexity of the equipment required for accurate performance verification, the following tests are intended only as gross indicators of proper operation.

2-11. These checks consist of connecting the output of a properly energized Noise Generator to a high sensitivity power meter. The indicated power will be a function of the noise bandwidth of the specific unit under test. Since the Noise Generators do not cut off sharply at their band edges, a specific power level for each unit cannot be stated, and only a minimum level is required for operational verification.

2-12. Connect the BNC INPUT of the Noise Generator to a regulated +28 volt DC source. The following AILTECH instruments are capable of providing the requisite power:

13611 Precision Test Receiver

7511 Precision Automatic Noise Figure Indicator (PANFI)

7512 PANFI

7514 PANFI

7300 Series System Noise Monitors (SNM-all models)

Alternatively, a regulated laboratory power supply capable of providing +28 volts DC at 20 mA may be used.

2-13. With the DC supply turned off, connect the noise OUTPUT of the Noise Generator to the power head of a high sensitivity RF (10 MHz to 18 GHz) power meter capable of measuring levels down to –70 dBm.

2-14. Turn on the +28V supply (MANUAL ON mode of the 75 PANFI and 7300 SNM). Note the indication of the power meter. The following are the minimum readings that should occur:

Part Number	Minimum Power Level (dBm)
7615	–67
7616	–58
7617	–61
7618	–56
7618E	–56
7626	–56

2-15. Field maintenance and repair are not recommended for AILTECH 7600 Series Noise Generators; therefore, if a unit fails the operational check described above, contact your local Eaton Corporation, Electronic Instrumentation Division (AILTECH) representative for instructions on return of the Noise Generator for repair (refer to paragraph 5-3).

SECTION 3

OPERATION

3-1. GENERAL

3-2. This section describes operation of the Noise Generators in typical noise figure and effective input noise temperature measurement setups. Additional details on these measurements can be found in the instruction manuals pertaining to the noise measuring instruments (PANFI, SNM, Precision Test Receiver).

3-3. CONTROLS, INDICATORS AND CONNECTORS

3-4. There are no controls or indicators and only two connectors – BNC female INPUT, Type N male or SMA female OUTPUT – on the AILTECH 7600 Series Noise Generators.

3-5. TYPICAL SETUPS

3-6. Figures 3-1 through 3-3 are block diagrams of typical setups using AILTECH 7600 Noise Generators for noise figure or effective input noise temperature measurement.

CAUTION

Two precautions should be observed when connecting the Noise Generator OUTPUT to the input of the device-under-test (DUT).

1. If there is a DC voltage present on the center conductor of the DUT input connector, a DC block should be inserted between the Noise Generator OUTPUT and the DUT input to prevent damage to the Noise Generator. The RF loss (in dB) of the DC block should then be subtracted from the calibrated ENR of the Noise Generator to obtain the actual ENR for measurement purposes.

2. If there is a possibility of large amounts of RF power (i.e., greater than 2 watts peak, 1/2 watt average) being present at the DUT input, the Noise Generator should be protected by an appropriately rated isolator. The RF loss (in dB) of the isolator should be subtracted from the calibrated ENR of the Noise Generator to obtain the actual ENR for measurement purposes.

3-7. Figure 3-1 illustrates two setups that can be used for noise figure or effective input noise temperature measurements by means of the manual Y-factor technique. Figure 3-2 shows a setup which measures noise figure directly. Figure 3-3 is a typical arrangement for automated noise figure or simultaneous noise figure and gain measurements over a band of frequencies using the IEEE STD-488 Interface Bus.

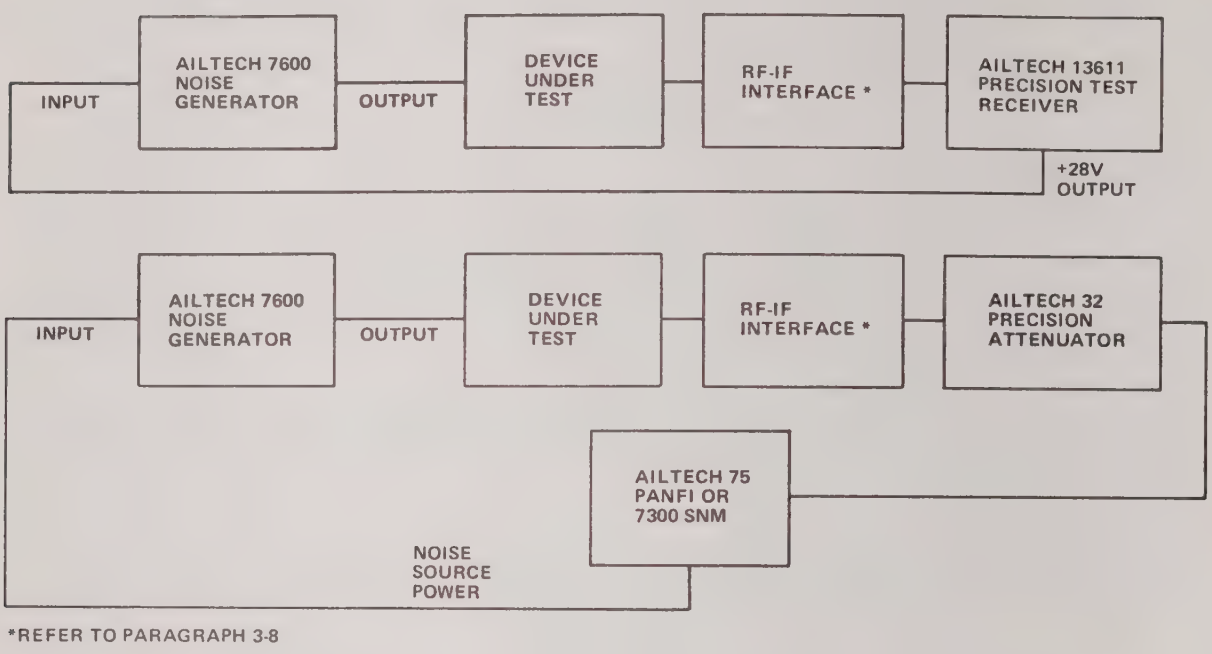


Figure 3-1. Typical Manual Measurement Setups

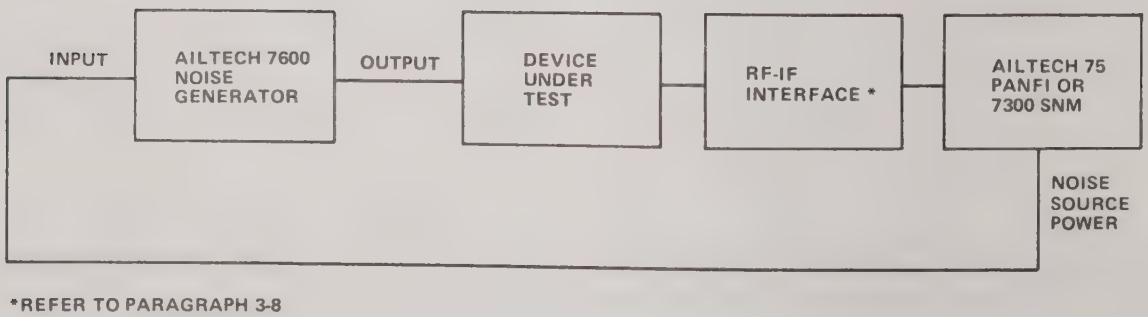


Figure 3-2. Typical Noise Figure (Direct Reading) Setup

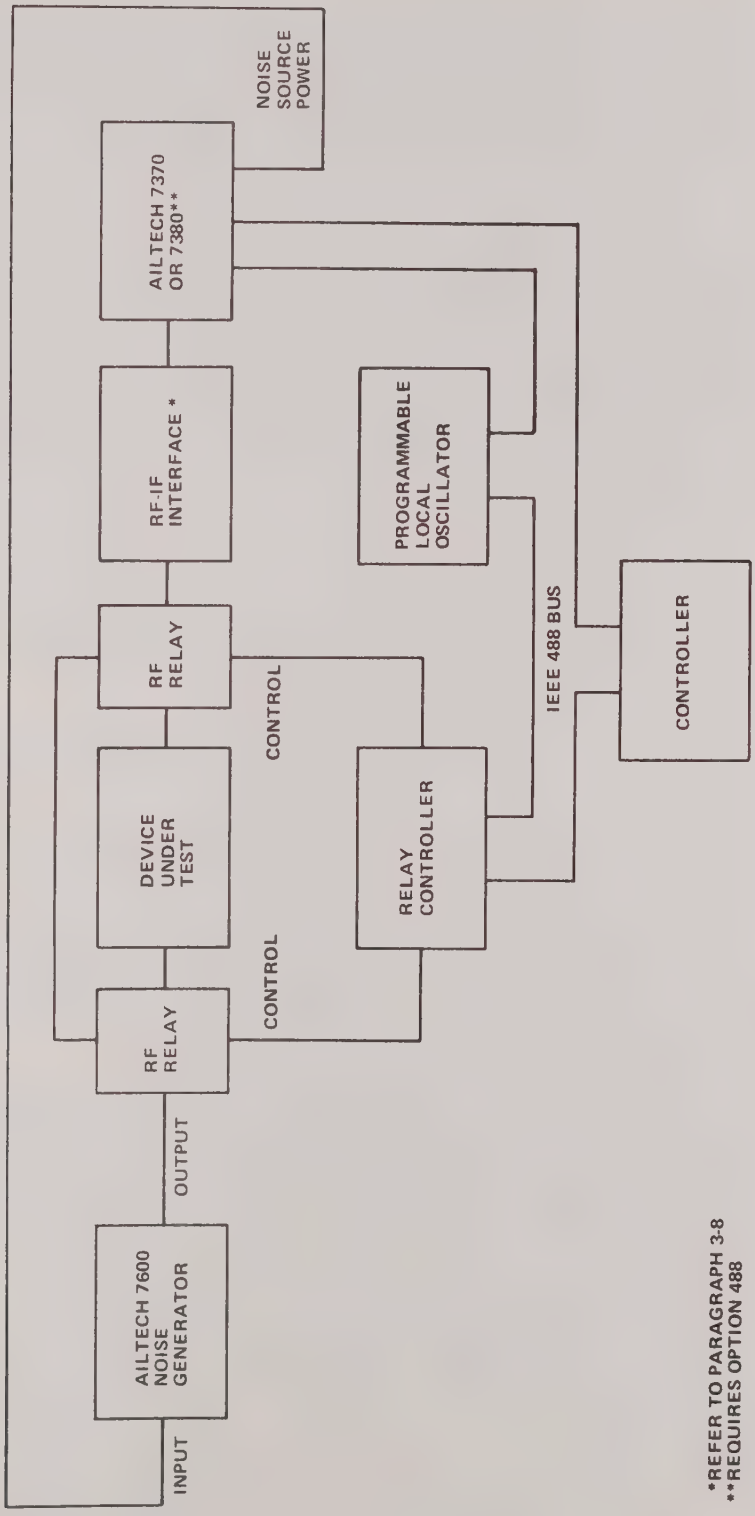


Figure 3-3. Typical Automated Setup for Noise Figure (7370) or Simultaneous Noise Figure and Gain (7380) Measurements

3-8. RF-IF INTERFACE

3-9. Most accurate, precision receiver noise measuring instruments operate at one of the accepted intermediate frequencies, typically 30 MHz. If the DUT output frequency is not compatible with the input frequency of the indicator (Test Receiver, PANFI, or SNM), a mixer-preamplifier (with an appropriate local oscillator, if required) must be inserted ahead of the indicator. Refer to paragraph 3-11.

3-10. Receiver noise measuring instrumentation has a minimum sensitivity level. If the DUT output is below this level (see the specifications for the indicator used), the measurement will be in error. It will then be necessary to add gain ahead of the indicator. Refer to paragraph 3-11.

3-11. A line of preamplifiers, mixers, high-sensitivity options, etc., is available for the purposes described above. Consult the AILTECH Noise Figure Instrumentation brochure, if the indicator is a 136 Precision Test Receiver or 75 PANFI, or the System Noise Monitoring brochure, if the indicator is a 7300 SNM, for details on these features.

3-12. MANUAL Y-FACTOR TECHNIQUE

3-13. Connect the equipment as indicated in Figure 3-1. With the Noise Generator turned off (MANUAL OFF using the 75 PANFI or 7300 SNM); i.e., 0 volts applied to the BNC INPUT, set the Precision Attenuator (integral to the 13611 Precision Test Receiver) to a convenient reference indication – typically, 10 dB.

3-14. Adjust the indicator gain for an on-scale reference reading.

3-15. Energize the Noise Generator by applying +28 volts to the BNC INPUT (MANUAL ON using the 75 PANFI or 7300 SNM).

3-16. Increase the setting of the Precision Attenuator until the indicator returns to the reference noted in paragraph 3-14. The *change* in the Precision Attenuator setting is the Y-factor in dB.

3-17. Read the calibrated ENR (dB) from the chart on the body of the Noise Generator or the Calibration Record accompanying the unit. Because of the high degree of ENR flatness with frequency of AILTECH 7600 Noise Generators, straight-line interpolation may be used to determine the ENR if the operating frequency differs from one of the calibration points.

3-18. Use equation (3-1) to determine noise figure or equation (3-2) to determine effective input noise temperature. Note that in both equations Y-factor is expressed as a power ratio, and the change noted in paragraph 3-16 must be appropriately converted from dB. Note also that equation (3-2) requires conversion of the ENR to a power ratio.

$$F_{dB} = ENR_{dB} - 10LOG_{10}(Y\text{-}1) \qquad (3\text{-}1)$$

$$T_e = \left(\frac{ENR}{Y\text{-}1} - 1 \right) \quad 290 \qquad (3\text{-}2)$$

3-19. Alternatively, the nomograph in Figure 3-4 or the AILTECH Noise Figure Slide Rule in Figure 3-5 may be used to calculate either quantity. The slide rule is available from:

Eaton Corporation
Electronic Instrumentation Division
5340 Alla Road,
Los Angeles, Ca. 90066

3-20. DIRECT READING AND AUTOMATED MEASUREMENTS

3-21. The AILTECH 7600 Series Noise Generators can also be used with instruments such as the AILTECH 75 PANFI and 7300 System Noise Monitors to provide real-time, direct reading noise figure measurements. The Noise Generators can also be used in automated setups based on the 7370 and 7380 System Noise Monitors equipped with the optional IEEE-STD-488 Interface Bus. The setups are outlined in Figures 3-2 and 3-3. Refer to the Instruction Manual applicable to the specific Monitor or PANFI in use for detailed operating instructions.

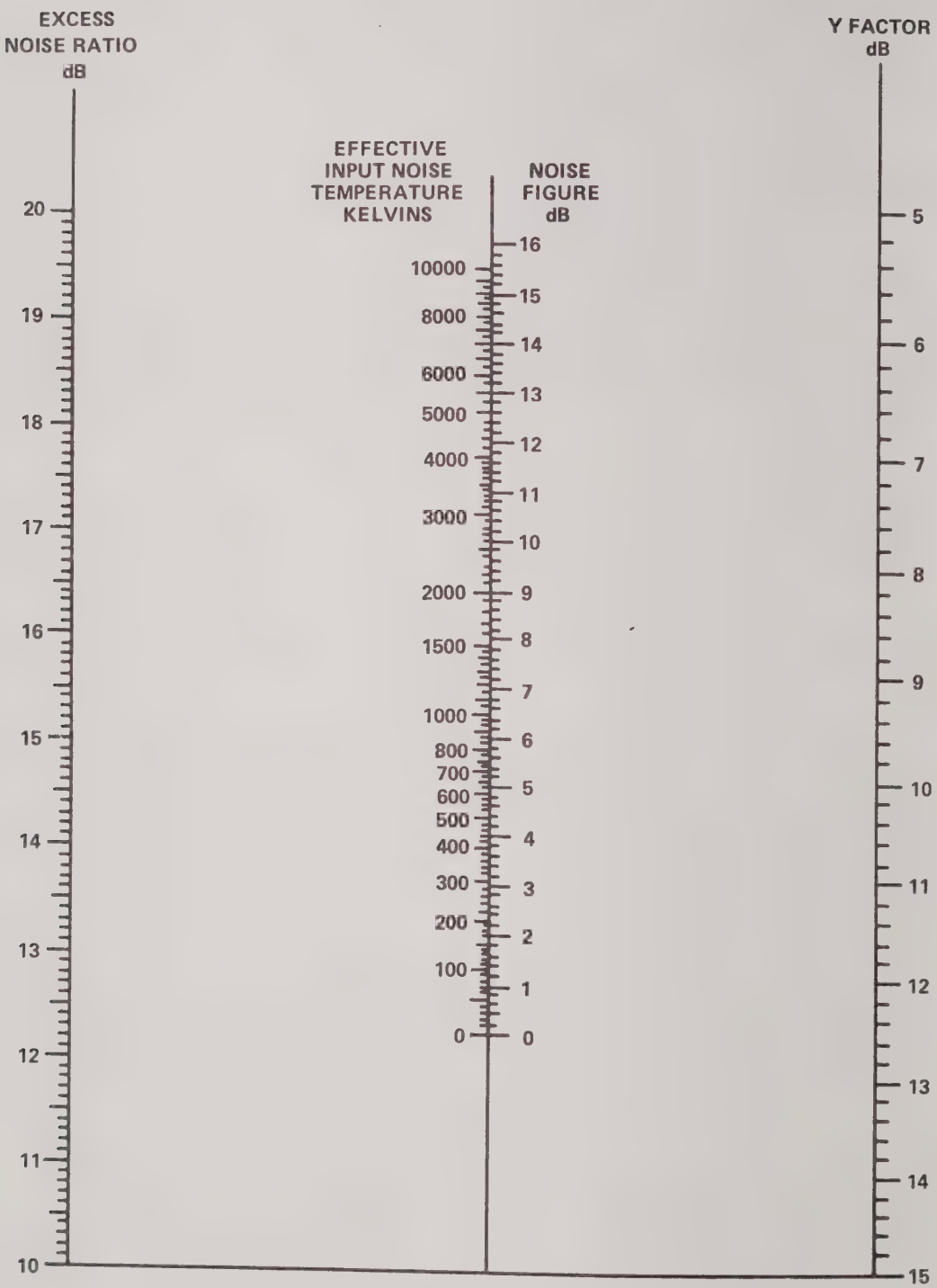
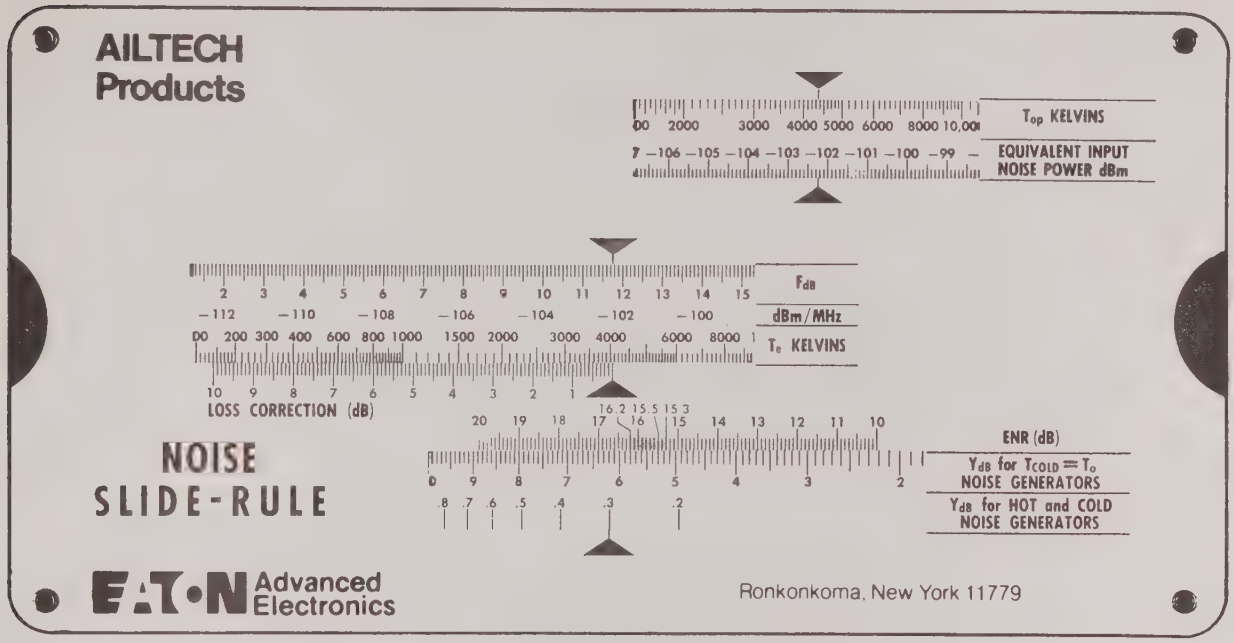


Figure 3-4. Nomograph for Determining Noise Figure or Temperature



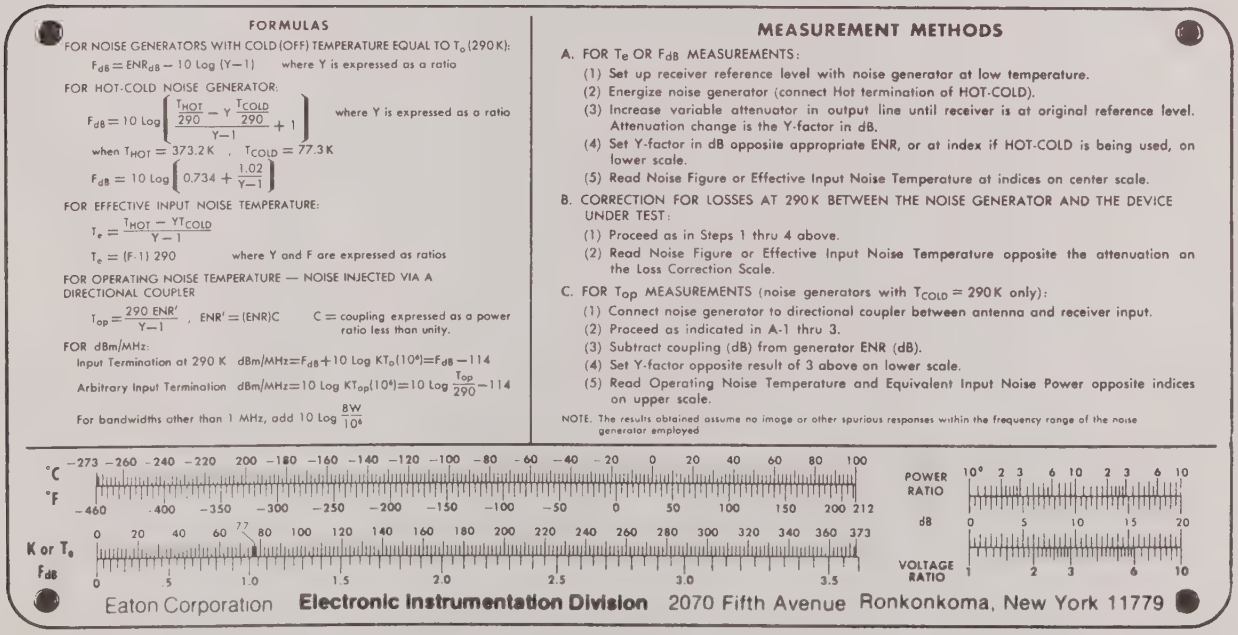

FORMULAS
FOR NOISE GENERATORS WITH COLD (OFF) TEMPERATURE EQUAL TO T_o (290 K):
$F_{dB} = ENR_{dB} - 10 \text{ Log } (Y-1)$ where Y is expressed as a ratio
FOR HOT-COLD NOISE GENERATOR:
$F_{dB} = 10 \text{ Log} \left\{ \frac{\frac{T_{HOT}}{290} - Y\frac{T_{COLD}}{290}}{Y-1} + 1 \right\}$ where Y is expressed as a ratio
when $T_{HOT} = 373.2$ K , $T_{COLD} = 77.3$ K
$F_{dB} = 10 \text{ Log} \left\{ 0.734 + \frac{1.02}{Y-1} \right\}$
FOR EFFECTIVE INPUT NOISE TEMPERATURE:
$T_e = \frac{T_{HOT} - YT_{COLD}}{Y-1}$
$T_e = (F-1)\ 290$ where Y and F are expressed as ratios
FOR OPERATING NOISE TEMPERATURE — NOISE INJECTED VIA A DIRECTIONAL COUPLER
$T_{op} = \frac{290\ ENR'}{Y-1}$, $ENR' = (ENR)C$ C = coupling expressed as a power ratio less than unity.
FOR dBm/MHz:
Input Termination at 290 K $dBm/MHz = F_{dB} + 10 \text{ Log } KT_o(10^6) = F_{dB} - 114$
Arbitrary Input Termination $dBm/MHz = 10 \text{ Log } KT_{op}(10^6) = 10 \text{ Log } \frac{T_{op}}{290} - 114$
For bandwidths other than 1 MHz, add $10 \text{ Log } \frac{BW}{10^6}$
MEASUREMENT METHODS
A. FOR T_e OR F_{dB} MEASUREMENTS:
(1) Set up receiver reference level with noise generator at low temperature.
(2) Energize noise generator (connect Hot termination of HOT-COLD).
(3) Increase variable attenuator in output line until receiver is at original reference level. Attenuation change is the Y-factor in dB.
(4) Set Y-factor in dB opposite appropriate ENR, or at index if HOT-COLD is being used, on lower scale.
(5) Read Noise Figure or Effective Input Noise Temperature at indices on center scale.
B. CORRECTION FOR LOSSES AT 290 K BETWEEN THE NOISE GENERATOR AND THE DEVICE UNDER TEST:
(1) Proceed as in Steps 1 thru 4 above.
(2) Read Noise Figure or Effective Input Noise Temperature opposite the attenuation on the Loss Correction Scale.
C. FOR T_{op} MEASUREMENTS (noise generators with $T_{COLD} = 290$ K only):
(1) Connect noise generator to directional coupler between antenna and receiver input.
(2) Proceed as indicated in A-1 thru 3.
(3) Subtract coupling (dB) from generator ENR (dB).
(4) Set Y-factor opposite result of 3 above on lower scale.
(5) Read Operating Noise Temperature and Equivalent Input Noise Power opposite indices on upper scale.
NOTE. The results obtained assume no image or other spurious responses within the frequency range of the noise generator employed
°C
°F
K or T_e
F_{dB}
POWER RATIO
dB
VOLTAGE RATIO
Eaton Corporation Electronic Instrumentation Division 2070 Fifth Avenue Ronkonkoma, New York 11779

Figure 3-5. AILTECH Noise Figure Slide Rule

SECTION 4

THEORY OF OPERATION

4-1. GENERAL DESCRIPTION

4-2. The AILTECH 7600 Series Noise Generators are made up of a diode module containing the noise generating element and a bias network, and a coaxial attenuator. An aluminum case slides over the assembled units to maintain the integrity of their interconnection and to provide general protection against physical damage in the event of mishandling. The block diagram of the Noise Generator is shown in Figure 4-1.

4-3. DIODE MODULE

4-4. The diode module is assembled in a rectangular, gold-plated, machined case. The case contains two compartments: one, housing the bias network; the other, the noise generating diode. Separation of the bias network from the diode helps insure an RF *tight* structure and noise output stability.

4-5. The stability and precision of the noise output is also insured by utilization of precision resistors in the bias network. These resistors are selected at test for best overall flatness of the noise output over the applicable frequency range.

4-6. The bias network supplies controlled current to the noise diode network – a hybrid, microwave integrated circuit. When power is applied, the diode breaks over into the avalanche mode producing a broad flat noise spectrum with an equivalent ENR in the range of 27 to 35 dB depending upon the model. The noise is coupled via microstrip to the diode module output connector.

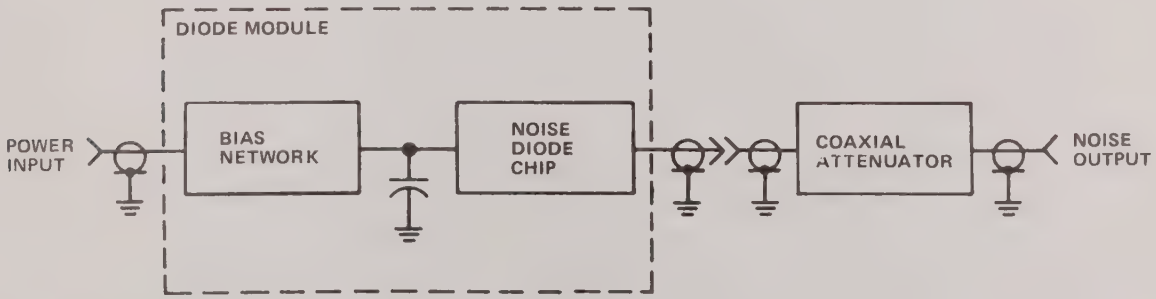


Figure 4-1. AILTECH 7600 Noise Generator Block Diagram

4-7. COAXIAL ATTENUATOR

4-8. The diode module output is connected to a high quality, stable, precision attenuator. The purpose of the attenuator is three-fold:

1. It reduces the ENR to a level compatible with most industry-accepted noise measuring instruments.
2. It reduces the output VSWR to the very low values required for accurate noise measurements.
3. It maintains the output impedance essentially constant as the noise generator is switched on and off (there will be some small shifts in reflection coefficient magnitude and/or phase; however, these will be negligible for almost all applications).

SECTION 5

MAINTENANCE AND ADJUSTMENTS

5-1. GENERAL

5-2. Because of the integrated construction of the noise generators, and the complexity of the test equipment required for maintenance and calibration; troubleshooting (beyond the Initial Checkout of paragraph 2-9) and field repair are not recommended.

5-3. FACTORY SERVICE

5-4. In the event a unit fails the checkout procedure (paragraph 2-9) or a malfunction is suspected, contact your nearest Eaton Corporation, Electronic Instrumentation Division Regional Office or Sales Representative by letter, TWX or phone. Please indicate the model number, serial number and specific details of the difficulty involved.

5-5. Should it be necessary to return the equipment for repair or recalibration, please contact Eaton Corporation, Electronic Instrumentation Division or an authorized sales representative in your area before shipping a unit. In your communication arranging for a return, please be sure to include model number, serial number, date of purchase and specific details concerning the problem (in the event of failure) or service desired (in the event of recalibration).

SECTION 6

REPLACEABLE PARTS

6-1. There are no recommended spares or field replaceable parts for the AILTECH 7600 Series Noise Generators.

AILTECH

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